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ABSTRACT

The performance of 144 pairs of college students on four successive concept attainment problems was assessed. A 3 x 2 x 2 x 4 factorial design with repeated measures on the last factor was used with the following variables: (a) type of interaction format (cooperation with discussion allowed during solution of the problems, cooperation with discussion not allowed, or competition), (b) memory aid (available or not available), (c) sex (male or female pairs), and (d) problems (four for each pair). Major results were: (a) discussion resulted in better performance on all measures (except time to solution) than did non-discussion or competition, which did not differ significantly; (b) on successive problems, discussing pairs increased their use of the more efficient focusing strategy and decreased time to solution, while non-discussing and competitive pairs showed no change; (c) memory aids resulted in fewer card choices to solution and fewer untenable hypotheses; and (d) no sex differences with the exception that females required less time to solution than males. (BW)

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# CONCEPT LEARNING BY PAIRS AS A FUNCTION OF TYPE OF INTERACTION, MEMORY REQUIREMENTS, AND SEX

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July 31, 1972

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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The research reported herein was performed pursuant to a contract with the Office of Education, U. S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

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Summary

Previous research had shown that the performance of two-person groups on a basic concept learning task was enhanced by cooperative discussion, but the precise effects of cooperation and discussion individually had not been ascertained. These earlier results, however, did suggest that these variables would have differential effects on the two processes that had been postulated for group concept learning: development of an efficient problem solving strategy and effective monitoring of a partner's performance. Consequently, the performance of 144 pairs of college students on four successive concept attainment problems was assessed. A 3 x 2 x 2 x 4 factorial design with repeated measures on the last factor was used with the following variables: (a) type of interaction format (cooperation with discussion allowed during solution of the problems, cooperation with discussion not allowed, or competition), (b) memory aid (available or not available), (c) sex (male or female pairs), and (d) problems (four for each pair). Major results were: (a) discussion resulted in better performance on all measures (except time to solution) than did non-discussion or competition, which did not differ significantly; (b) on successive problems, discussing pairs increased their use of the more efficient focusing strategy and decreased time to solution, while non-discussing and competitive pairs showed no change; (c) memory aids resulted in fewer card choices to solution and fewer untenable hypotheses; and (d) no sex differences with the exception that females required less time to solution than males. The results extend previous findings on the facilitative effects of cooperative discussion and reduced memory requirements. The results further suggest two important implications for educational practice: (a) decrements in performance which result from competitive learning situations may simply reflect the lack of cooperative communication that is inherent in competition; and (b) sex differences in cognitive performance, where they are found, may reflect motivational rather than ability differences.

## Introduction

Bruner, Goodnow, and Austin (1956) introduced a concept learning situation which has subsequently been widely used in the study of individual cognitive processes. In this situation, an array of cards varying in a number of attributes (shape, color, etc.) with two or more values of each attribute (triangle or square, red or green, etc.) is placed before the learner. The experimenter arbitrarily designates two or more values in some logical combination (e.g., red triangle, red or triangle, etc.) as a concept and indicates an initial card which exemplifies this concept. The learner must then determine what attributes have been designated by selecting any succession of cards he wishes, learning whether or not each card exemplifies the concept, and thus reasoning to a solution in as few card choices as possible. The sequence of card choices and accompanying hypotheses may be analyzed to determine the strategy or problem solving process used.

Recently, Laughlin and his associates have extended this situation to the study of group performance (e.g., Laughlin, McGlynn, Anderson, & Jacobson, 1968). A recent review by Davis (1969a) noted that these studies "have provided one of the few lines of precise experimental investigation of group performance with tasks emphasizing learning (p. 56)."

An important feature of these investigations has been the development of quantitative rules by which focusing strategy can be scored (Laughlin, 1968). Focusing is an attribute-testing process or plan which minimizes the inference and memory requirements of the task relative to scanning strategy which tests hypotheses. In focusing, the subject selects a card differing in one value from the initial card. If the selected card is also an example of the concept, the changed value is irrelevant to the concept, while if the selected card is a non-example, the changed value is essential to the concept. If just one value is changed, the strategy is called conservative focusing, while changing more than one is called focus gambling because a person gambles on obtaining a positive card. In group concept learning, then, the focusing score reflects the degree to which the group formulates an overall problem solving strategy. In addition to this <u>strategy process</u>, a distinct <u>monitoring process</u> by which individuals can check on each others' card choices and hypotheses has been suggested by the results of some studies (Anderson, 1968; Laughlin & Doherty, 1967; McGlynn, 1972). This process has been measured quantitatively by the percentage of untenable hypotheses. An hypothesis, which must be offered after each card selection, is called untenable if it contradicts available information in any way. Both these measures of problem-solving <u>processes</u> may be distinguished from the basic problem-solving <u>product</u> measure of number of card choices to solution.

In an extensive study of individual versus two-person cooperative

group performance in the concept attainment situation, Laughlin et al. (1968) found that dyads needed fewer card choices, had fewer untenable hypotheses, and employed more focusing strategy. But as Davis (1969b) has suggested, the question of individual or group superiority may be only a special case of the more general question of how individuals "turn into groups" or combine to achieve the final group product. Studies varying the type of dyadic interaction are relevant to this question of social combination processes.

Laughlin and Doherty (1967) compared cooperative pairs allowed discussion with cooperative pairs not allowed discussion as part of a larger factorial design. Groups allowed discussion solved the problems in fewer card choices and made fewer untenable hypotheses, but did not differ significantly in the use of focusing strategy. Laughlin and McGlynn (1967), comparing cooperative pairs allowed discussion with two competitive individuals, found that cooperative pairs used more focusing strategy in addition to making fewer untenable hypotheses and requiring fewer card choices. Hence, it appears from these two studies that discussion results in more effective problem solving for cooperative discussing pairs as reflected in the problem-solving product (fewer card choices) and in the monitoring process (fewer untenable hypotheses). With regard to the strategy process, however, it is the introduction of competition rather than non-discussion by itself that results in less use of focusing strategy by non-discussing pairs. The three formats for interaction (discussion, non-discussion, and competition) were compared in this experiment in order to determine precisely the effects of competition and discussion on the processes that have been postulated.

Within this basic framework, two variables which were known to affect concept learning performance were also investigated. Both the memory requirements of the task and the sex of the subjects may be important determinants of the social combination processes.

Although studies of individual concept learning have shown memory requirements to be an important variable (see Dominowski, 1965), studies with dyads (Laughlin & Doherty, 1967; Laughlin et al., 1968) have found no effect for memory except in interaction with other variables. In both studies the manipulation involved either allowing or prohibiting the use of paper as a memory aid. However, since McGlynn (1967) observed that many subjects failed to use the paper at all, the obtained interactions might well be due to differential use of the aids, and the conclusion of Laughlin and Doherty (1967) that the effects of discussion are relatively more important than the effects of memory may be unwarranted. Recently, Laughlin (1969) has reported an improved methodology for manipulating the memory variable. In the memory aid condition the subject is permitted to physically remove the selected cards to areas designated "examples" or "non-examples." Using this procedure Laughlin (1969) found a significant main effect for memory requirements which held

over a rather wide variety of conditions with individual subjects.

The two studies which have examined sex differences in dyadic concept learning (Laughlin & McGlynn, 1967; Laughlin et al., 1968) have found no overall differences. There is, however, evidence to suggest that males benefit relatively more from cooperative discussion with regard to the strategy process (Laughlin et al., 1968), although the cooperative pairs of Laughlin and McGlynn (1967) did not replicate this finding. In addition, Laughlin et al. (1968) found that females had fewer card choices and untenable hypotheses with memory aids available than males. Without memory aids, there was no sex difference in card choices to solution, but males made fewer untenable hypotheses than females.

The purpose of the present study was to extend knowledge about the performance of small groups on the basic learning task of concept attainment and to resolve the conflicting findings cited above. Thus, the experiment was designed to test the effects of type of interaction (cooperation with discussion, cooperation without discussion, and competition), memory requirements, and sex on concept learning and the processes which result in learning.

## Method

### Design and Subjects

A 3 x 2 x 2 x 4 factorial design with repeated measures on the last factor was used with the following variables: (a) format (discussion, no discussion, or competition), (b) memory aid (available or not available), (c) sex (male or female pairs), and (d) problems (four for each pair). Subjects were 288 college students enrolled in psychology courses at Texas Tech University, serving as research subjects as part of the course requirement. Twelve like-sex pairs were randomly assigned to each of the 12 experimental conditions.

### Stimulus Display and Problems

The stimulus display was an 8 x 8 array of 64 2½ x 4 inch cards. These cards represented all possible combinations of six plus and/or minus signs in a row. In order to facilitate reference to the six positions, each was a different color, so that the color name was the attribute and the plus or minus, the value of each color. The cards were in a systematic arrangement; for example, the top four rows were blue plus and the bottom four rows were blue minus. All problems had three relevant attributes and were selected at random from the total set of possible three-attribute conjunctive problems. All pairs solved four three-attribute problems.

### Procedure and Instructions

The instructions thoroughly explained with examples the nature of the task and the conjunctive concept rule. In all conditions, subjects sat adjacent to each other before the display. In the cooperative conditions, the task was explained as an experiment in

cooperative problem solving in which the subjects were not competing with each other in any way. Where discussion was allowed, the pair was instructed to discuss the problems and their card choices and hypotheses, but to alternate in actually stating each card choice and accompanying hypothesis. Where discussion was prohibited, they were instructed to listen carefully to each other's card choices and hypotheses and attempt to use this information although they could not engage in any discussion. Again, they were told to alternate in stating the card choice and hypothesis. In the competitive conditions, the pair was instructed that the object was to solve the problem before the other person. In all conditions, the person who selected the first card and made the first hypothesis was selected by a coin flip, and all pairs were instructed to solve the problem in as few card choices as possible, regardless of time. In conditions where memory aids were available, chosen cards were moved to an appropriate area of the table designated "example" or "non-example." When no memory aid was available, subjects had to remember which cards from the array had been chosen and whether each was an example or not.

For all problems, the experimenter began by indicating an initial card which was an example of the concept. The designated subject then selected any card he wished, learned if it was an example or not, and made an hypothesis as to what concept was correct. Subjects alternated in this procedure until a correct hypothesis was made. (See Appendix A for complete instructions.)

## Results

### Card Choices to Solution

The means for number of card choices to solution for each of four problems and totals over problems are given in Table 1, and the results of the analysis of variance are in Table 2.

The main effect for Format was significant ($p < .001$). Using the Tukey procedure (Winer, 1962), comparisons of the individual treatment means revealed that cooperative discussing pairs required significantly fewer card choices to solution than either cooperative non-discussing or competitive pairs ($p < .01$), which did not differ significantly from each other. Dyads allowed the use of memory aids had fewer card choices to solution than those without memory aids, but the difference was only marginally significant ($p < .08$). None of the other main or interaction effects were significant.

Table 1
Means for Number of Card Choices

| Format | Problem | Memory Aid | | No Memory Aid | | Total |
|---|---|---|---|---|---|---|
| | | Male | Female | Male | Female | |
| Discussion | 1 | 4.33 | 3.92 | 4.83 | 4.50 | 4.40 |
| | 2 | 4.25 | 4.58 | 4.50 | 5.83 | 4.79 |
| | 3 | 4.08 | 4.08 | 4.17 | 3.67 | 4.00 |
| | 4 | 3.58 | 3.58 | 3.83 | 4.33 | 3.83 |
| | Total | 4.06 | 4.04 | 4.33 | 4.58 | 4.26 |
| Non-discussion | 1 | 7.17 | 4.92 | 6.42 | 6.00 | 6.13 |
| | 2 | 5.25 | 5.42 | 7.08 | 6.83 | 6.15 |
| | 3 | 4.58 | 4.17 | 7.83 | 6.08 | 5.67 |
| | 4 | 5.25 | 4.75 | 6.67 | 7.08 | 5.94 |
| | Total | 5.56 | 4.81 | 7.00 | 6.50 | 5.97 |
| Competition | 1 | 5.58 | 6.58 | 5.83 | 6.58 | 6.15 |
| | 2 | 6.00 | 5.58 | 6.00 | 3.58 | 5.29 |
| | 3 | 5.58 | 4.33 | 6.00 | 6.00 | 5.48 |
| | 4 | 6.58 | 6.83 | 5.67 | 6.25 | 6.33 |
| | Total | 5.94 | 5.83 | 5.88 | 5.60 | 5.81 |

Table 2
Analysis of Variance for Card Choices to Solution

| Source | df | M. S. | F |
|---|---|---|---|
| Sex (A) | 1 | 7.79 | < 1 |
| Format (B) | 2 | 172.35 | 10.17* |
| Memory (C) | 1 | 53.17 | 3.14 |
| A x B | 2 | 6.64 | < 1 |
| A x C | 1 | .50 | < 1 |
| B x C | 2 | 36.48 | 2.15 |
| A x B x C | 2 | .73 | < 1 |
| Error (B) | 132 | 16.94 | |
| Problems (D) | 3 | 6.57 | < 1 |
| A x D | 3 | 4.48 | < 1 |
| B x D | 6 | 8.42 | < 1 |
| C x D | 3 | 5.19 | < 1 |
| A x B x D | 6 | 8.75 | < 1 |
| A x C x D | 3 | 2.56 | < 1 |
| B x C x D | 6 | 9.69 | < 1 |
| A x B x C x D | 6 | 5.09 | < 1 |
| Error (W) | 396 | 13.07 | |

* $p < .001$

Focusing Strategy

The means for focusing strategy for each of four problems and total over problems are given in Table 3, and the results of the analysis of variance are in Table 4.

Table 3
Means for Focusing Strategy

| Format | Problem | Memory Aid | | No Memory Aid | | Total |
|---|---|---|---|---|---|---|
| | | Male | Female | Male | Female | |
| Discussion | 1 | .44 | .54 | .59 | .31 | .47 |
| | 2 | .69 | .61 | .66 | .49 | .61 |
| | 3 | .59 | .59 | .79 | .68 | .66 |
| | 4 | .74 | .76 | .72 | .68 | .73 |
| | Total | .61 | .63 | .69 | .54 | .62 |
| Non-discussion | 1 | .40 | .46 | .43 | .45 | .44 |
| | 2 | .52 | .37 | .56 | .28 | .43 |
| | 3 | .48 | .41 | .37 | .45 | .42 |
| | 4 | .47 | .53 | .50 | .40 | .47 |
| | Total | .47 | .44 | .47 | .39 | .44 |
| Competition | 1 | .42 | .27 | .29 | .32 | .33 |
| | 2 | .42 | .47 | .40 | .48 | .44 |
| | 3 | .37 | .50 | .51 | .47 | .46 |
| | 4 | .42 | .39 | .31 | .37 | .37 |
| | Total | .41 | .41 | .38 | .41 | .40 |

Table 4
Analysis of Variance for Focusing Strategy

| Source | df | M. S. | F |
|---|---|---|---|
| Sex (A) | 1 | .1627 | 1.22 |
| Format (B) | 2 | 2.5219 | 18.95*** |
| Memory (C) | 1 | .0292 | < 1 |
| A x B | 2 | .0949 | < 1 |
| A x C | 1 | .1083 | < 1 |
| B x C | 2 | .0036 | < 1 |
| A x B x C | 2 | .1161 | < 1 |
| Error (B) | 132 | .1330 | |
| Problems (D) | 3 | .3948 | 4.58** |
| A x D | 3 | .0665 | < 1 |
| B x D | 6 | .1962 | 2.28* |
| C x D | 3 | .0893 | 1.04 |
| A x B x D | 6 | .0854 | < 1 |
| A x C x D | 3 | .0030 | < 1 |
| B x C x D | 6 | .0406 | < 1 |
| A x B x C x D | 6 | .0932 | 1.08 |
| Error (W) | 396 | .0862 | |

*** $p < .001$
** $p < .01$
* $p < .05$

Focusing strategy was scored by two rules. Rule 1: Each card choice had to obtain information on one new attribute. New information was obtained if the card choice altered only one attribute not previously proven irrelevant (conservative focusing) or, if more than one attribute was altered (focus gambling), the instance was either positive or the ambiguous information from a negative instance was correctly resolved on the next card by altering only one attribute. Rule 2: The hypothesis accompanying each card choice had to be tenable considering the information already available. The total number of instances that satisfied these two rules was divided by the total number of card choices on the problem to obtain a continuous focusing score from .00 to 1.00.

The main effect of Format was significant ($p < .001$). Tukey tests showed that cooperative discussing pairs employed more focusing strategy than either cooperative non-discussing or competitive pairs ($p < .01$), which did not differ significantly from each other. Neither the main effect of memory nor sex was significant. The effect of successive problems was significant ($p < .01$). There was less use of the focusing strategy on problem 1 than either 3 ($p < .05$) or 4 ($p < .01$). None of the other interproblem differences were significant. The Format x Problems interaction was significant ($p < .05$). An analysis of simple main effects showed that this interaction was the result of a significant increase in the use of focusing on successive problems by cooperative discussing pairs ($p < .01$) while cooperative non-discussing and competitive pairs exhibited no significant change in focusing over problems. The cooperative discussing pairs failed to differ significantly from the other two interaction formats on the first problem only.

Untenable Hypotheses

The means for the untenable hypothesis ratio for each of the four problems and totals over problems are given in Table 5, and the results of the analysis of variance are in Table 6.

An hypothesis which contradicted available information in any way was considered untenable. The total number of untenable hypotheses was divided by the total number of hypotheses less one (i.e., the correct hypothesis is tenable by definition and was not counted).

The main effect of Format was significant ($p < .001$). Tukey tests showed that cooperative discussing pairs had a lower untenable hypothesis ratio than either cooperative non-discussing or competitive pairs ($p < .01$), which did not differ significantly. Dyads allowed the use of memory aids had a significantly lower untenable hypothesis ratio than those without memory aids ($p < .05$). The effect of successive problems was marginally significant ($p < .07$), but Tukey tests revealed that the decrease in untenable hypothesis ratio over problems did not result in any significant interproblem differences.

Table 5
Means for Ratio of Untenable Hypotheses

| Format | Problem | Memory Aid | | No Memory Aid | | Total |
|---|---|---|---|---|---|---|
| | | Male | Female | Male | Female | |
| Discussion | 1 | .14 | .16 | .30 | .34 | .24 |
| | 2 | .15 | .27 | .23 | .42 | .27 |
| | 3 | .15 | .29 | .16 | .24 | .21 |
| | 4 | .05 | .23 | .18 | .24 | .17 |
| | Total | .12 | .24 | .22 | .31 | .22 |
| Non-discussion | 1 | .49 | .42 | .33 | .54 | .44 |
| | 2 | .45 | .38 | .39 | .58 | .45 |
| | 3 | .41 | .37 | .49 | .37 | .41 |
| | 4 | .30 | .22 | .39 | .42 | .33 |
| | Total | .41 | .35 | .40 | .48 | .41 |
| Competition | 1 | .42 | .51 | .55 | .56 | .51 |
| | 2 | .36 | .38 | .50 | .46 | .43 |
| | 3 | .36 | .25 | .35 | .35 | .33 |
| | 4 | .53 | .46 | .52 | .43 | .49 |
| | Total | .42 | .40 | .48 | .45 | .44 |

Table 6
Analysis of Variance for Untenable Hypothesis Ratio

| Source | df | M. S. | F |
|---|---|---|---|
| Sex (A) | 1 | .1133 | < 1 |
| Format (B) | 2 | 2.6242 | 21.20*** |
| Memory (C) | 1 | .6467 | 5.23** |
| A x B | 2 | .2188 | 1.77 |
| A x C | 1 | .0448 | < 1 |
| B x C | 2 | .0107 | < 1 |
| A x B x C | 2 | .0987 | < 1 |
| Error (B) | 132 | .1238 | |
| Problems (D) | 3 | .2111 | 2.43* |
| A x D | 3 | .0466 | < 1 |
| B x D | 6 | .1589 | 1.83 |
| C x D | 3 | .0376 | < 1 |
| A x B x D | 6 | .0442 | < 1 |
| A x C x D | 3 | .0248 | < 1 |
| B x C x D | 6 | .0703 | < 1 |
| A x B x C x D | 6 | .0508 | < 1 |
| Error (W) | 396 | .0870 | |

*** $p < .001$
** $p < .05$
* $p < .07$

Time to Solution

The means for time to solution in minutes for each of four problems and totals over problems are given in Table 7, and the results of the analysis of variance are in Table 8.

Table 7
Means for Time to Solution in Minutes

| Format | Problem | Memory Aid | | No Memory Aid | | Total |
|---|---|---|---|---|---|---|
| | | Male | Female | Male | Female | |
| Discussion | 1 | 11.33 | 8.92 | 11.83 | 10.58 | 10.67 |
| | 2 | 7.58 | 6.83 | 8.25 | 8.83 | 7.88 |
| | 3 | 7.50 | 5.75 | 6.42 | 4.17 | 5.96 |
| | 4 | 6.92 | 3.92 | 5.75 | 4.92 | 5.38 |
| | Total | 8.33 | 6.35 | 8.06 | 7.13 | 7.47 |
| Non-discussion | 1 | 7.58 | 5.17 | 6.50 | 4.58 | 5.96 |
| | 2 | 4.83 | 5.17 | 5.92 | 4.50 | 5.10 |
| | 3 | 4.00 | 4.00 | 5.58 | 3.67 | 4.31 |
| | 4 | 6.08 | 3.92 | 4.58 | 3.83 | 4.60 |
| | Total | 5.63 | 4.56 | 5.65 | 4.15 | 4.99 |
| Competition | 1 | 5.25 | 5.92 | 5.33 | 5.83 | 5.58 |
| | 2 | 4.25 | 4.83 | 5.17 | 2.58 | 4.21 |
| | 3 | 4.33 | 3.25 | 4.67 | 4.25 | 4.13 |
| | 4 | 4.50 | 4.58 | 4.17 | 4.50 | 4.44 |
| | Total | 4.58 | 4.65 | 4.83 | 4.29 | 4.59 |

Table 8
Analysis of Variance for Time to Solution in Minutes

| Source | df | M. S. | F |
|---|---|---|---|
| Sex (A) | 1 | 142.01 | 5.10* |
| Format (B) | 2 | 466.60 | 16.77*** |
| Memory (C) | 1 | 0.00 | < 1 |
| A x B | 2 | 20.81 | < 1 |
| A x C | 1 | 0.00 | < 1 |
| B x C | 2 | 2.51 | < 1 |
| A x B x C | 2 | 9.85 | < 1 |
| Error (B) | 132 | 27.82 | |
| Problems (D) | 3 | 216.57 | 12.19*** |
| A x D | 3 | 3.46 | < 1 |
| B x D | 6 | 51.61 | 2.91** |
| C x D | 3 | 2.67 | < 1 |
| A x B x D | 6 | 9.71 | < 1 |
| A x C x D | 3 | 10.95 | < 1 |
| B x C x D | 6 | 12.68 | < 1 |
| A x B x C x D | 6 | 5.06 | < 1 |
| Error (W) | 396 | 17.77 | |

*** $p < .001$
** $p < .01$
* $p < .05$

The main effect for Sex was significant as females required less time to solution than males ($p < .05$). The effect of Format was significant ($p < .001$) such that discussing pairs required more time to solve the problems than either non-discussing or competitive pairs ($p < .01$), which did not differ significantly from each other. The significant main effect for successive problems ($p < .001$) was the result of significantly greater time to solution on problem 1 relative to the last three problems, which did not differ significantly. These latter two significant main effects were qualified by the significant Format x Problems interaction which showed that discussing pairs required significantly more time than non-discussing or competitive pairs on the first two problems only ($p < .01$) and that discussion resulted in significantly faster solution over successive problems ($p < .01$) while there was no change with the other two formats.

Correlations between Response Measures

Correlations between the four response measures overall and within each of the three interaction formats are given in Table 9.

Table 9
Intercorrelations of Response Measures

| | | | | |
|---|---|---|---|---|
| **Overall** | | | | |
| | | CC | F | UH |
| | F | -.60 | | |
| | UH | .62 | -.69 | |
| | T | .58 | -.36 | .30 |
| **Discussion** | | | | |
| | | CC | F | UH |
| | F | -.53 | | |
| | UH | .59 | -.64 | |
| | T | .66 | -.44 | .35 |
| **Non-discussion** | | | | |
| | | CC | F | UH |
| | F | -.63 | | |
| | UH | .66 | -.71 | |
| | T | .78 | -.56 | .55 |
| **Competition** | | | | |
| | | CC | F | UH |
| | F | -.59 | | |
| | UH | .55 | -.63 | |
| | T | .83 | -.51 | .47 |

## Conclusions

The basic finding of this study was that two cooperating discussing individuals were more effective on the concept learning task than either two cooperating individuals not allowed discussion or two competing individuals. This greater effectiveness was evidenced on both the basic measure of problem solving product (card choice to solution) and the two measures of problem solving process (focusing strategy and untenable hypothesis ratio), although discussing pairs required more time to solution initially. Non-discussing and competitive pairs did not differ significantly on any of the four dependent measures.

Furthermore, discussion on successive problems resulted in an increase in the use of the more efficient attribute-testing strategy of focusing and a decrease in time to solution. Over successive problems there were no significant changes for focusing or time to solution for either non-discussing cooperative pairs or competitive pairs. Hence, these interaction formats seem to have inhibited learning across problems.

These findings point to the overall conclusion that discussion, as opposed to either cooperation without discussion or competition, results in better problem solving and, in time, more logical or elegant solutions as indicated by the increased use of focusing strategy. Since there were no differences on any of the dependent measures for non-discussion and competition, it is reasonable to conclude that there are no inhibiting effects of competition on this task beyond the lack of discussion. Thus, there is some support for the conclusion of Laughlin and McGlynn (1967) that their results reflected the facilitative effect of discussion rather than the detrimental effect of excessive motivation which sometimes accompanies competition.

Although these results on interaction formats are in substantial agreement with previous studies comparing cooperative discussion and non-discussion (Laughlin & Doherty, 1967) and cooperative discussion and competition (Laughlin & McGlynn, 1967), the differences should be noted. (a) Laughlin and Doherty (1967) found no differences in the use of focusing strategy between discussing and non-discussing dyads whereas discussion resulted in more focusing in the present study. (b) The increases in focusing and decreases in time to solution over problems, which were observed in the present study only for discussing dyads, were also found for competitive dyads by Laughlin and McGlynn (1967). (c) These investigators also found an overall decrease across problems in card choices, while in the present study there was no effect of successive problems for this measure.

Contrary to previous studies (Laughlin & Doherty, 1967; Laughlin et al., 1968) in which memory requirements were manipulated by

either allowing or forbidding the use of paper and pencil, the results of the present experiment with a more effective memory manipulation showed significant effects for the memory variable. Removing cards chosen from the stimulus display and grouping them into sets of positive and negative examples resulted in a significantly lower untenable hypothesis ratio and marginally significantly fewer card choices with no differences for focusing strategy. Thus, it can be concluded that reduced memory requirements result in fewer faulty inferences (perhaps through improved monitoring within the dyad) and a slight improvement in overall performance (card choices to solution) without having any effect on development of a more effective problem solving strategy. The failure of any of the interactions involving the memory variable to reach significance indicates that this conclusion holds for all three of the formats tested in the present study.

Laughlin and Doherty (1967) concluded that the efficient performance of cooperative pairs on the concept attainment task was due to discussion while memory requirements had no effect. The results of this study lead to the conclusion that while discussion is clearly the more important factor, reduced memory requirements may also improve performance. This experiment also extends to competitive pairs the previous finding that the use of memory aids is not sufficient to overcome the decrement in performance that accompanies the lack of discussion.

The findings of Laughlin et al. (1968) that with paper and pencil allowed females required fewer card choices to solution and had a lower untenable hypothesis ratio than males were not replicated and should probably be attributed to a greater tendency on the part of females to make use of such memory aids. No sex differences were found in the present study with the exception that females required less time to solution than males, extending the previous finding (Laughlin & McGlynn, 1967) that females required less time with both discussion and competition formats. As noted earlier, Laughlin et al. (1968) reported that male pairs employed more focusing strategy than female pairs while Laughlin and McGlynn (1967) found no sex differences on this measure for either cooperative or competitive pairs. The results of the present experiment, then, support the findings of Laughlin and McGlynn (1967) and reinforce their conclusion that the concept attainment task is probably sufficiently interesting for females to motivate them to perform on a level equal with males. Hoffman (1965) noted the frequently observed superiority of males in problem solving and attributed it to motivation rather than ability differences. Finally, the failure to find any interaction between sex and cooperation versus competition replicates the results of Laughlin and McGlynn (1967) and is a further indication that the generalization from coalition research (Gamson, 1964) that females are anticompetitive in problem solving situations does not hold for the concept attainment task.

Since the concept attainment situation represents a basic learning task, the results of this investigation are relevant to educational practice to the extent that a given learning task can be analyzed into processes analogous to those postulated for concept learning. Such processes would include abstraction, reasoning, inference, and the development of an efficient strategy for learning or problem solving. Additionally, in the case of group learning, this investigation has implications for the type of interaction that might be arranged in a classroom situation.

The basic finding of this study that the superiority of a cooperative over a competitive format is due to a lack of communication in competition cautions against interpreting the ineffectiveness of competitive learning formats as being the result of tension or excessive motivation. For example, Haines and McKeachie (1967) compared cooperative and competitive techniques of teaching discussion sections of a general psychology course and found that competition resulted in higher tension, less satisfaction, and poorer achievement in recitation. Although these authors attributed the poorer performance associated with competition to the increase in tension, it is also possible that the performance decrement was partly the result of decreased discussion and communication among the students. Hence, in situations where the consequences of failure are not so severe as to indicate extreme tension (the effect of "losing" in the present study was trivial), the effects of competition may be equivalent to other procedures which do not involve cooperative discussion. In short, there is evidence from the present study that, by itself, competition which lacks severe consequences does not inhibit performance on a basic learning task.

On the other hand, the benefits of cooperative discussion which have been demonstrated over and over again in this line of research (Laughlin, 1965; Laughlin & Doherty, 1967; Laughlin & McGlynn, 1967; Laughlin et al., 1968; McGlynn, 1972) should be emphasized once more on the basis of the findings of the present study. The results suggest that on complex cognitive tasks cooperative discussion is markedly superior to other types of interaction. More importantly, it leads to a more efficient learning strategy over time.

The findings of the present study with regard to the memory variable indicate that although reducing memory requirements on a learning task such as this may enhance performance in some respects, such enhancement is likely to occur independent of the type of interaction format. Thus, a classroom teacher might employ either competition or cooperation without regard to the memory requirements of the task so long as they are moderate as in this kind of concept learning task. Finally, the failure of this research to find any substantial sex differences should caution educators to look for motivational explanations when sex differences in cognitive performance are observed.

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Appendix A
Instructions to Subjects

(Discussion and Non-discussion. This is an experiment in cooperative problem solving, so you two are in no way competing with each other. Your scores will be compared with those of other groups only.)

(Competition. This is an experiment in competitive problem solving. The object is to solve the problem before the other person does.)

There are 64 cards on this table, arranged in eight rows of 8 cards each and numbered from 1 to 64. These cards are all the possible combinations made by taking six colors, each color being either a plus or a minus. The colors are called attributes, and the plus and minus are called values. (Point out the six colors, the plus and minus, and the systematic arrangement of the cards and the values.)

These cards can be grouped together or categorized in a large number of possible ways by following a specified rule. This rule defines a concept, and a concept is the group of all cards that satisfy that rule. The rule is that the card must have three particular values (plus or minus) on three particular colors. For example, all the cards with a black plus, a yellow plus, and a green minus are the concept "black plus, yellow plus, green minus". Or, all the cards with a blue minus, orange minus, and red plus are the concept "blue minus, orange minus, red plus". Can you find a card with the concept "blue minus, orange minus, red plus"?

In the problems I will have some concept in mind, and your job will be to determine what it is. I'll start you off by giving you the number of one of the cards that is included in the concept; that is, one of the group of cards that exemplify the concept I have in mind. Then you will select any card you wish to in order to get information as to whether the card you select is also included in the concept. If the card you select is included in the concept, I will say "yes". (Memory Aid. ...and you can place the card in the "yes" space.) If the card you select is not included in the concept, I will say "no". (Memory Aid. ...and you can place the card in the "no" space.) To be included in the concept, the card must exactly satisfy the rule. For instance, if you choose a card with a blue plus, yellow plus, red plus and my concept is "blue plus, yellow plus, red minus", the card will not be included in the concept.

Next, you will make a hypothesis as to what concept you think I have in mind. If your hypothesis is correct, I'll say "yes", and you will have solved the problem. If your hypothesis is not correct, I'll say "no". A "no" means that your hypothesis is not entirely correct, although it might be partially correct. For instance, if you say "blue plus, yellow plus, red plus" and the concept I have

in mind is "blue plus, yellow plus, green plus", your hypothesis will be incorrect and I will say "no".

(Discussion. If I say "no" to your hypothesis, you select another card and again I'll say "yes" or "no" depending upon whether or not the card you select is included in the concept, and again you will make a hypothesis and I'll say "yes" or "no" to the hypothesis. You keep repeating the procedure of selecting a card and making a hypothesis until you have solved the problem.)

(Non-discussion. If I say "no" to your hypothesis, your partner selects another card and again I'll say "yes" or "no" depending upon whether or not the card chosen is included in the concept, and then that person makes a hypothesis and I'll say "yes" or "no" to the hypothesis. You keep alternating the procedure of selecting a card and making a hypothesis until you have solved the problem.)

(Competition. If I say "no" to your hypothesis, your opponent selects a card and again I'll say "yes" or "no" depending upon whether or not the card chosen is included in the concept, and then that person makes a hypothesis and I'll say "yes" or "no" to the hypothesis. You keep alternating the procedure of selecting a card and making a hypothesis until one of you solves the problem.)

(Discussion and Non-discussion. You may take as much time as you wish to think about your card choices and hypotheses since the object is to solve the problem in as few card choices as possible, regardless of time.)

(Competition. You may take as much time as you wish to think about your card choices and hypotheses since the object is to solve the problem before the other person does, regardless of time.)

(Discussion. Since we are interested in cooperative problem solving, you are asked to discuss your card choices and hypotheses between you before deciding on each selection. Then you will take turns in being spokesman for your group. I will flip a coin to see who starts off as spokesman in the first problem. (Flip) After discussion, (name), you will choose the first card and make the first hypothesis after further discussion. In the next problem, (name), you will start off. You will solve four problems in all. Are there any questions?)

(Non-discussion. Since discussion with your partner is not allowed in this experiment, you are urged to listen carefully to each other's card choices and hypotheses and to attempt to use this information in solving the problem more easily.)

(Competition. Since discussion with your opponent is not allowed in this experiment, you are urged to listen carefully to each other's

card choices and hypotheses and to attempt to use this information in solving the problem more easily.)

(Non-discussion and Competition. In a minute I will flip a coin to see who starts off by choosing the first card and making the first hypothesis. From then on you will take turns in choosing cards and making your hypotheses throughout all four problems. (Flip) Are there any questions?)

In the first problem I have a concept in mind, and card number ___ is a member of that concept.

(Memory Aid. (Name), you may move that card to the "yes" space since it is a member of the concept.)

(Discussion. Now you may discuss your first card choice, and then your spokesman can tell me your choice.)

(Non-discussion and Competition. Now, (name), you may choose your first card and then make your first hypothesis. (To other) Be sure and listen to his (her) choices and hypotheses and make good use of the information.)